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(54) Ion beam implanter for providing cross plane focusing

Ionenimplantier-Gerät mit Fokusiereigenschaften in der Ebene senkrecht zur Rasterebene

Implanteur d'ions produisant un focalisation dans le plan perpendiculaire au plan de balayage

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Description

Field of the Invention

The present invention concerns an ion implanter for treating workpieces and more specifically concerns an ion implanter that is particularly suited for implanting semiconductor wafers with doping impurities.

Cross Reference to Related Patents

Commonly owned U.S. patent 5,091,655 to Dykstra *et al.*, discloses an ion implantation system for treating semi-conductor wafers. The Dykstra *et al.* disclosure includes a focusing lens for maintaining uniform angle of impact between ions and a workpiece, the lens having a single, arcuate entrance electrode.

Background Art

It is known in the semiconductor fabrication art to use an ion beam to dope semiconductor wafers with ion impurities. By scanning an ion beam across a wafer surface or moving the wafer through a stationary beam the wafer can be uniformly doped.

The angle at which an ion beam impacts a wafer surface (wafer tilt) is an important parameter in ion implantation of the wafer. Recent trends in semiconductor material processing require a greater range of wafer tilt capability, typically 0-60 degrees, while decreasing the variation of the ion impact angle across the wafer surface.

In a scanning ion beam system, electrostatic deflection plates produce a raster pattern of ion beam impingement on the wafer surface. One set of plates produces a rapid back and forth scan in one direction and a second set of plates provides beam deflection in an orthogonal direction. Such raster scanning results in impact angle variations of ±4° of the central ray of the beam across a 200 mm wafer for a typical scanning ion beam geometry.

Methods have been proposed to reduce this impact angle variation. One proposal suggests using four sets of deflection plates, two horizontal and two vertical, and is referred to as a double deflection system. The beam is first deflected away from an initial trajectory and then, before striking the wafer, is deflected again to return to a direction parallel to its original, undeflected trajectory.

Use of a double deflection system with large wafer diameters requires deflection plates that are more widely spaced. This requires high deflection voltages that must be scanned and precisely synchronized with the scanning voltages applied to the first set of deflection plates. Another problem is that as the opening in the scan plates increases, electrostatic fringing fields become more difficult to control and become more susceptible to beam space charge effects.

Another known method of reducing tilt variations is to use a mechanically scanned, spinning disk wafer support. If the spin axis is parallel to the beam, no impact angle variations are present. Spinning disk supports have problems achieving control over impact angle while maintaining the necessary condition for an impact angle variation. One example of a prior art patent having a spinning workpiece support is U.S. patent 4,794,305 to Matsukawa.

Another more recent approach is to electrostatically scan the beam in one axis, and then use a highly indexed bending magnet to produce a parallel ribbon beam. The semiconductor wafer target is also scanned mechanically in a direction orthogonal to the ribbon beam to produce a uniform two dimensional implant. U. S. patents 4,276,477 to Enge, 4,687,936 to McIntyre *et al.* and 4,922,106 to Berrian *et al.* disclose such systems.

To define an ion beam used for implantation, one often refers to the median and range of impact angles for the beam against the workpiece. To help characterize the median and range, two orthogonal planes are defined; the parallelizing plane and the cross plane. The parallelizing plane is the plane seen from the top view of the lens in the '655 patent to Dykstra *et al.* and is also referred to as the scan plane since this is the plane in which the beam scans back and forth. The cross plane is seen as a section view through the lens that bisects the lens along the direction of beam travel. The Dykstra *et al.* disclosure does not address the problem of controlling ion redeflection in the cross plane.

Disclosure of the Invention

In one aspect, this invention provides the ion implant system defined by claim 1, 12 or 14, the preambles of which reflect the state of the art according to US patent 5,091,655, already mentioned. In another aspect, the invention provides the ion accelerator defined by claim 7. In a further aspect, the invention provides the method for ion beam implanting a workpiece defined by claim 15.

The disclosed ion beam implant system treats a workpiece, typically a semi-conductor wafer, by causing ions to impact the wafer at a controlled, uniform angle in both the cross and the parallelizing planes.

Ions emitted by an ion source form an ion beam moving in a first trajectory. Ions move along this first trajectory to a magnet which preferentially deflects ions of the correct mass and charge along a second trajectory. An electrode pair deflects ions away from this second trajectory by a controlled amount to produce a side-to-side scan. A beam accelerator accelerates ions deflected by the controlled amount before they impact a workpiece. A control circuit having an output coupled to the side-to-side scan electrode pair adjusts the deflecting of the ion beam and thereby controls ion beam treatment of the workpiece.

The beam accelerator includes entrance electrodes

biased at control voltages for creating a non-uniform electric field. In the disclosed and preferred design, first and second entrance electrodes form arcuate or curved conductive electrode surfaces having a slot or throughpassage that passes through the first and second entrance electrode. The gap between electrodes, thickness of the electrodes, curvature of the electrodes, electrical potential of each, and slot dimensions can all be adjusted to control impact angle. The non-uniform electric field created by these electrodes preferably causes ions following diverse trajectories to be redeflected so they impact the workpiece at a relatively uniform angle. One or more additional electrodes accelerate or decelerate the ions after they have been redeflected so they impact the workpiece with an appropriate energy. These additional electrodes are only required if the desired beam energy is different that the sum of the energies imparted by an extraction power supply and a lens power supply.

The cross plane focusing imparted to a charged particle beam through a simple slotted acceleration gap is generally inversely proportional to the slot width and the gap length. It is proportional to the applied voltage and the angle at which the beam enters the slot. Shaping the electric fields near the slot by thickening the electrodes in which the slots are formed increases the cross plane focusing. The entrance electrode is more sensitive to the thickness change as the particles have lower energy at the entrance to the beam accelerator.

Variation of cross plane focusing in the ion beam increases if the beam enters the accelerator at a large input angle near the ends of the slot or throughpassage due to the side to side scanning. The gap-defining electrodes are curved to impart the parallelizing action described in U.S. patent 5,091,655 so that this angle is further increased.

In the parallelizing or scan plane, the bending angle is independent of the gap length and it has been found that if the gap length is varied across the width of the lens, the cross plane focusing variation with input angle is diminished.

The cross plane focusing near the center of the lens is increased by thickening the first curved electrode near the center and thinning it near the ends of the slots.

The above corrections to the cross plane focus do interact with the parallelizing or scan plane in a way that affects the parallelizing action. It appears, however, that a suitable compromise can be achieved for scanned beam ribbons of about 25 cm (10 inches) in width and for beam transport distances of about 45 cm (18 inches) from the scan electrodes.

Various objects, advantages and features of the invention will become better understood from the accompanying detailed description of one embodiment of the invention which is described in conjunction with the accompanying drawings.

Brief Description of the Drawings

Figures 1A and 1B schematically depict an ion implantation system constructed in accordance with the invention;

Figure 2 is an enlarged partially sectioned view of an ion beam acceleration tube;

Figure 3 is a section view of the Figure 2 structure showing first and second curved entrance electrodes;

Figure 4 is an elevation view of one of two curved entrance electrodes of the Figure 2 ion beam acceleration tube;

Figure 5 is a partially section plan view of the Figure 4 curved entrance electrode;

Figure 6 is a section view of the entrance electrode as seen from the plane 6-6 defined in Figure 5;

Figure 7 is an elevation view of a second of two curved entrance electrodes of the Figure 2 ion beam electrode structure;

Figure 8 is a partially sectioned plan view of the Figure 7 electrode;

Figure 9 is a sectioned view of the second entrance electrode as seen from the plane 9-9 in Figure 8;

Figure 10 is a schematic showing a spread of ion beam angles of incidence as an ion beam impacts a workpiece;

Figure 11 is a perspective view of two elongated parallel ion-deflecting plates;

Figure 12 is a section view taken perpendicularly through the two parallel plates of Figure 11;

Figure 13 is a section view taken at an oblique angle through the two parallel plates defined by the line 13-13 in Figure 11;

Figure 14 is a section view of two parallel electrodes showing fringe fields between the electrodes; and

Figures 15-17 show variations in electrode construction to modify ion beam focusing in the cross plane.

Detailed Description of One Embodiment

Turning now to the drawings, Figures 1A and 1B illustrate an ion implantation system 10 having an ion source 12 (Fig. 1A) for generating an ion beam 14. The source 12 includes a filament that emits electrons which ionize gas molecules within a source ionization chamber. The filament is activated by a filament power supply 13 which energizes the filament. An extraction power supply 15 maintains a bias between an extraction electrode 17 and the source 12 of approximately 15-40 kV. This causes ions emitted from the source 12 to accelerate and follow a trajectory that leads to an ion mass analyzing magnet 16.

The source 12 is positively biased with respect to the magnet 16. The magnet 16 bends ions having an appropriate mass to charge ratio through approximately 90 degrees to a travel path through a shutter 20. The

shutter 20 rejects ions having an inappropriate mass to charge ratio from the ion beam 14.

Beam ions that pass through the shutter 20 enter a region bounded by a pair of deflection electrodes 26, 28. Voltages applied to the electrodes 26, 28 by a beam deflection circuit 29 cause the ion beam 14 to be deflected by a controlled amount. The magnitude of the voltage difference between the two plates 26, 28 controls the amount of this deflection, and by varying this voltage the circuit 29 can cause the beam to sweep across a fan-like range of trajectories.

The deflected ion beam enters a beam accelerator tube 30 where ions are again deflected, as well as accelerated. Ions following diverging trajectories due to deflection by the electrodes 26, 28 are deflected by the accelerator tube 30 to spaced, generally parallel trajectories in the scan plane.

The beam accelerator tube 30 includes first and second curved metallic entrance electrodes 32, 33 (Figure 3) and a plurality of spaced, parallel metallic electrodes 34a-34e that create an electric field for accelerating ions in the beam. After passing through the accelerator tube 30, ions in the beam have been both redirected to a desired trajectory and accelerated to a final implantation energy.

Downstream from the acceleration tube 30, an ion implantation station 40 includes a wafer support 50 that positions a semiconductor wafer to intercept ions. Ion beam collisions with other particles degrade beam integrity so that the entire beam travel path from the source 12 to the implantation station 40 is evacuated. Two pumps 52, 54 maintain low pressure within the ion implantation system 10. At the region of the ion implantation station 40 a chamber is evacuated and the wafers are inserted into and withdrawn from load locks to avoid repeated pressurization and depressurization of the chamber. Such mechanisms are known in the prior art.

The scanning electrodes 26, 28 produce side-to-side beam scanning of a controlled amount under the direction of the beam deflection circuitry 29. This circuitry includes a programmable controller for adjusting the scanning electrode voltages to achieve this wafer scanning. The particular ion implantation system depicted in Figures 1A and 1B produces only side-to-side scanning so that to implant an entire workpiece surface of a circular wafer, for example, an additional relative motion between the deflected ion beam and the workpiece is necessary. In this implementation, a linear back and forth scan of the wafer support 50 (perpendicular to the plane of the ribbon ion beam) is achieved through suitable drive mechanisms (not shown) attached to a wafer support.

As seen most clearly in Figures 3-6, the entrance electrode 32 of the accelerator tube 30 forms an arcuate surface facing ions entering the tube. The electrode 32 is maintained at a fixed potential. A second electrode 33 is biased negatively with respect to the first electrode by a power supply 62 (Figure 1B). The voltage difference between the first electrode 32 and the second electrode is maintained at a fixed proportion of the extraction voltage. For this geometry, the voltage difference between the first electrode and second electrode is maintained at 1.6 times the extraction voltage.

As seen in Figure 3, the electrodes 34a-34e are separated by insulators 70 which electrically isolate each electrode from an adjacent electrode as well as space the electrodes relative to each other. Bias resistors R (Figure 1B) are electrically connected between the electrodes 34a-34e and across the acceleration power supply 63 and system ground to produce approximately the same voltage difference between adjacent electrodes. Each resistor R has a resistance of approximately 250 megohms.

The electric field set up by the accelerator tube 30 redeflects ions moving in divergent paths due to the side to side scanning of the electrodes 26, 28 into paths which are generally parallel to each other in the scan plane. The redeflected ions are accelerated and exit the accelerator tube 30 having trajectories which cause the ions to impact wafers on the wafer support 50 at a relatively uniform impact angle. By appropriate orientation of the wafer support, this angle can be perpendicular or at other predetermined impact angles.

When discussing beam parallelism, the parallelism must be discussed in the context of both the average impact angle of the beam on a workpiece and the spread or deviation of that impact angle. As seen in the schematic depiction of Figure 10, it is possible to have a mean or average impact angle of zero degrees with the workpiece but have a large variation in the impact angle across the beam width. A most desirable beam from the standpoint of semiconductor processing is one where the medium, as well as range of impact angles, does not deviate from a specific value at all conditions and points across the semiconductor wafer.

To assess the success in achievement of this goal, the angular range and medium are broken up into range and medium angles in both the cross and scan planes. The parallelizing plane is the plane of Figure 1B. This plane is also referred to as the scan plane since it is the plane that the scan plates or electrodes 26, 28 sweep the beam back and forth through.

The cross plane is a plane taken through a section view of the acceleration tube such as the section view of Figure 12. In focusing an ion beam by using an electrostatic element, one must carefully determine the shape and gradient of both the entrance and exit electric fields in the vicinity of the electrostatic element.

In analyzing an electrostatic element, it is convenient to divide the field into two areas, a linear field region where the equal potential lines are approximately flat, and the fringing fields where the potential lines are substantially curved or bowed. The electrostatic field imparts energy and consequently causes a velocity change to the beam in a direction that is tangent to the equal potential lines. If the fringing fields did not exist,

the linear region of electric field would only accelerate or decelerate the beam in its original direction of travel and no cross plane focusing would occur. It is the bowing of the fringing fields which creates a focusing action. The desired amount of focusing is determined by considerations of all the optical elements in the beam line to provide an overall beam transport definition.

Turning now to Figure 11, this figure depicts an acceleration gap 71 defined by two infinitely long electrodes 72, 74. Two electrode portions that make up the electrode 72 are shown electrically connected together by a conductive jumper 76. A similar conductor couples together the two portions of the conductor 74. By describing an infinitely long pair of electrodes, it is possible to ignore fringing fields at the ends of the electrodes. A diverging beam 14 entering the gap 71, can be seen to be strongly converging due to the focusing effect of the electric field. Figure 12 is a section view, perpendicular to the electrodes in Figure 11, showing the ion beam 14 entering the electrodes with divergent velocity components in the cross plane subsequent to their being deflected in the scanning plane by the electrodes 26, 28 and being focused by the electric field set up by the electrodes 72, 74.

When the beam 14 is injected into electrodes 72, 74 at an oblique angle, fringing and linear regions that the beam encounters have a different focusing action compared to a beam injected perpendicularly into the electrodes. This effect is illustrated by comparing the depiction of the equipotential lines in Figure 13, which shows a view of the electrodes from the plane 13-13 in Figure 11, to the equipotential lines seen in Figure 12. The focusing of an electrostatic lens is seldom capable of being predicted in the form of closed form mathematic solution. Taking into account theoretical electrostatic considerations, however, an appropriate electrode construction based upon the beam geometry and the beam scanning can be modeled sufficiently accurately by a finite difference computer program. The detailed depiction of the electrodes 32, 33 discussed below is the result of one such model.

The amount of variation in the cross plane focusing depends on the curve shape of the lens and the ratio of the beam energy to lens voltage, both of which are generally selected based on parameters such as available power supplies, range of desired beam energy, and overall size of the system. Figure 14 shows the focusing at the center of two parallel electrodes 72', 74' where the beam is injected perpendicular to the electrodes. In order to reduce the focusing variation across the lens, it is necessary to modify the fringing fields differently at points along the electrode width. To accomplish focus control, three variations have been introduced:

1. Varying the length of the acceleration gap by increasing electrode separation, Figure 15. Increasing the width of the gap between the electrodes 72", 74", while holding the voltage constant decreases the voltage gradient in the linear region, which results in smaller fringing field. .

2. Varying the opening or throughpassage in the two electrodes, Figure 16. Although increasing the opening between spaced-apart portions of the two electrodes 72", 74" will result in a longer fringing field, the larger curvature of the field will result in the beam encountering a flatter region of the fringing field.

3. Varying the thickness of the two electrodes, Figure 17. This is a smaller effect than items 1 and 2, however, the shape of the fringing field is affected by the thickness of the electrodes and can be advantageously used in designing the electrodes. As seen in Figure 17, the electrode 82 is much thicker than the electrode 80.

By comparing Figure 14 to Figure 15, 16 and 17, one sees the relative changes that occur by varying these three parameters. The mix of variations is optimized by considering a large number of parameters, including the voltage across the lens, beam energy, beam size at the entrance electrode, beam angle of incidence, curvature of the lens, and voltages on surrounding electrodes.

A more detailed depiction of the accelerator tube 30 is shown in Figures 2 and 3. The entrance electrode 32 is attached to a metal plate 112 that abuts an upstream portion of the beam transport structure. A fluid-tight engagement between the plate 112 and this structure is maintained by "O" rings seated within slots 113 extending around the plate 112. In a similar fashion, a metal plate 114 at an opposite end of the acceleration tube 30 engages downstream structure of the ion implantation system and maintains a fluid-tight engagement by means of similar "O"-ring seals.

The entrance electrode 32 is attached to the plate 112 by means of connectors 118 that extend through the plate 112 and into threaded openings 120 in a mounting surface 122 (Figure 4) of top and bottom walls 124, 125 of the electrode 32. As seen most clearly in Figure 4, the electrode 32 is constructed from two symmetric metal castings that engage each other along a center line 126 of the electrode 32. The two halves of the electrode 32 are connected together by a splice plate 128 (Fig. 2). Connectors 129 extend through the splice plate 128 and engage threaded openings 130 extending through a side wall 132 of the electrode 32.

The electrode 32 defines a slot or throughpassage 134 that is elongated to accommodate the side-to-side scanning imposed on ions within the beam by the two deflection electrodes 26, 28. The slot 134 has a greater width W2 at its sides than in its middle where the slot has a width W1 of approximately 1.31 inches. As seen in Figures 5 and 6, the electrode 32 includes a curved wall 135 having a curved surface 136 extending across

the electrode 32 that surrounds the gap or throughpassage 134. Extending perpendicularly away from this curved surface 136 are upper and lower metal plates 138, 139 having curved edges 140, 141. The metal plates 138, 139 have contoured, inwardly facing surfaces 142, 143 conforming to the shape of the slot in the surface 136 and generally planar, outwardly facing surfaces 144, 145. The plates 138, 139 vary the thickness of the electrode 32 across the slot length. Two representative thicknesses T1, T2 are shown in Figure 5.

An insulator 150 abuts the plate 112 to which the electrode 32 is attached and spaces this electrode from the second curved electrode 33. This insulator 150 is preferably constructed from cast epoxy. Connectors 151 (Figure 2) pass through the insulator 150 to engage the plate 112.

A conductive plate 152 similar in construction to the electrodes 34a-34e abuts the insulator 150. The plate 152 supports the second arcuate electrode 33. Threaded connectors 154 extend through the plate 152 and engage corresponding threaded openings 156 in a mounting face 160 of top and bottom walls 161, 162 of the electrode 33. As seen most clearly in Figure 7, the electrode 33 is also constructed from two portions which engage each other along a center line 164 and are held together by two splice plates 166. Connectors 167 extend through the plate 166 and engage threaded openings 168 in side walls 169 of the electrode 33.

The electrode 33 defines a throughpassage 170 having the same shape as the throughpassage 134 in the electrode 32. More specifically, the throughpassage 170 in the electrode 33 narrows at its center and widens on its two sides. A width W3 of the center of the gap is approximately 5,25 cm (2.10 inches). A curved surface 172 of a curved electrode entrance wall 174 conforms generally to the curved edges 140, 141 on the electrode 32. Turning now to Figure 3, it is seen that the spacing between the electrodes 32, 33 varies across the length of the slot through the electrodes. Representative gaps G1, G2 are depicted in Figure 3.

The insulators 70 are cast epoxy members that extend radially outward from the accelerator tube. This radial extension inhibits arcing between adjacent electrodes 34a-34e. The resistors R are formed by insulated resistor elements that loop around the insulators 70. The electrodes 34a-34e are held in place by metal caps 180 that engage the insulators 70 and define openings through which connectors 182 are inserted to threadingly engage the electrodes 34a-34e.

The invention has been described in conjunction with a preferred embodiment of the invention. Although the preferred ion implanter is depicted having voltage polarities suitable for implanting positive ions, a system for implanting negative ions or electrons is possible. It is also possible to use a deceleration tube to focus ions in an ion beam. Such a tube would slow down rather than accelerate ions while narrowing the range of impact angles. It is the intent that the invention include all modifications and alterations from these embodiments falling within the scope of the appended claims.

Claims

1. An ion implant system for controllably treating a workpiece, comprising:

   source means (12) for providing ions to treat a workpiece;
   support means (50) for orienting the workpiece at a location relative the source means;
   beam forming means (16,17) for causing ions emitted by the source means to follow an initial trajectory;
   electrode means (26,28) for deflecting ions in said ion beam away from said initial trajectory by a controlled amount;
   lens means for again deflecting ions prior to said ions impacting the workpiece; and
   control means (29) having an output coupled to said electrode means to adjust the deflecting of said ion beam and thereby control ion beam treatment of the workpiece;
   characterized in that the lens means comprises first and second spaced electrodes (32,33) that define first and second elongated slots (134,170) for allowing ions to enter a spatially non-uniform electric field that causes ions following diverse trajectories after deflection by the electrode means to be redeflected and impact the workpiece at a relatively uniform angle, the first and second elongated slots (134,170) varying in width from a center region of the first and second slots to an outer portion of said first and second slots.

2. An ion implant system according to claim 1, wherein the first and second electrodes (32,33) have curved electrode surfaces (136,172) that vary the thicknesses of the first and second electrodes in a region bounding the elongated slots through which the ion beam passes on its way to the workpiece.

3. An ion implant system according to claim 1, comprising at least two additional electrodes (34) which consist of spaced, parallel electrode plates having apertures for transmitting ions passing through the elongated slots (134,170) to the workpiece.

4. An ion implant system according to claim 1, wherein the curved surfaces (136,172) of the spaced first and second electrodes (32,33) have differing curvature to vary a gap separation between the curved surfaces along the length of the first and second slots (134,170).

5. An ion implant system according to claim 1, comprising a lens power supply (62) for biasing the first and second electrodes (32,33) at different constant electric potentials for creating a static electric field in a region between the first and second electrodes.

6. An ion implant system according to claim 1, comprising acceleration means (30) for accelerating ions deflected by said controlled amount to said ions impacting the workpiece, the acceleration means comprising:

   first and second arcuate entrance electrodes (32,33), constituting said first and second spaced electrodes, said first and second elongated slots (134,170) thereof defining through passages symmetric about a centerline that are wider at locations spaced from the centerline than at the centerline;
   a plurality of additional, spaced, parallel electrode plates (34) for accelerating said ions to an impact energy;
   a plurality of insulators (70) separating said plates; and
   power supply means (62,63) for biasing said arcuate entrance electrode relative said plurality of parallel electrode plates such that a first (34a) of the additional electrodes is maintained at a fixed voltage by a high voltage power supply (63), a second (34e) of the additional electrodes is grounded, and the entrance electrode (33) is biased by a lens power supply (62) at a voltage higher than the first additional electrode (34a), whereby positively charged ions are accelerated to a controlled ion energy when striking the workpiece.

7. An ion accelerator adapted for use with the ion implant system of claim 1, the ion accelerator comprising:

   first and second entrance electrodes (32,33), biased at voltages for creating a non-uniform electric field that causes ions following diverse trajectories within said implant system to be deflected and impact a workpiece at a relatively uniform angle, said entrance electrodes defining elongated slots (134,170) extending therethrough that are generally symmetric about a plane passing through said first and second entrance electrodes, the slots each having a width that varies across the length of the slots;
   a plurality of additional, spaced electrodes (34) for accelerating said ions to an impact energy before striking the workpiece;
   a plurality of insulators (70) separating said additional electrodes; and
   power supply means (62,63) for electrically biasing the first and second entrance electrodes at electric potentials different from the plurality of additional electrodes to create the non-uniform electric field, and for electrically biasing the plurality of additional electrodes for accelerating the ions.

8. An ion accelerator according to claim 7, wherein a slot width is less at the center of the slot (134,170) and widens at positions removed from the center.

9. An ion accelerator according to claim 8, wherein the slot (134,170) widens uniformly on opposite sides of the slot.

10. An ion accelerator according to claim 7, wherein the first and second entrance electrodes (32,33) have curved surfaces that are spaced apart by a variable gap along the length of said elongated slots (134,170).

11. An ion accelerator according to claim 7, wherein a thickness of at least one of said first and second entrance electrodes (32,33) changes along a length of said elongated slot (134,170).

12. An ion implant system for controllably treating a workpiece, comprising:

   source means (12) for providing ions to treat a workpiece;
   support means (50) for orienting the workpiece at a location relative the source means;
   beam forming means (16,17) for causing ions emitted by the source means to follow an initial trajectory;
   electrode means (26,28) for deflecting ions in said ion beam away from said initial trajectory by a controlled amount;
   lens means for again deflecting ions prior to said ions impacting the workpiece; and
   control means (29) having an output coupled to said electrode means to adjust the deflecting of said ion beam and thereby control ion beam treatment of the workpiece;
   characterized in that the lens means comprises first and second spaced electrodes (32,33) that define first and second elongated slots (134,170) for allowing ions to enter a spatially non-uniform electric field that causes ions following diverse trajectories after deflection by the electrode means to be redeflected and impact the workpiece at a relatively uniform angle, at least one of the first and second electrodes (32,33) having a thickness that changes along the length of the elongated slots (134,170).

13. An ion implant system according to claim 12, wherein the first and second spaced electrodes (32,33) have first and second arcuate surfaces (136,172) that are spaced apart by a gap spacing that varies across the length of the elongated slots (134,170).

14. An ion implant system for controllably treating a workpiece, comprising:

source means (12) for providing ions to treat a workpiece;
support means (50) for orienting the workpiece at a location relative the source means;
beam forming means (16,17) for causing ions emitted by the source means to follow an initial trajectory;
electrode means (26,28) for deflecting ions in said ion beam away from said initial trajectory by a controlled amount;
lens means for again deflecting ions prior to said ions impacting the workpiece; and
control means (29) having an output coupled to said electrode means to adjust the deflecting of said ion beam and thereby control ion beam treatment of the workpiece;
characterized in that the lens means comprises first and second spaced electrodes (32,33) that define first and second elongated slots (134,170) for allowing ions to enter a spatially non-uniform electric field that causes ions following diverse trajectories after deflection by the electrode means to be redeflected and impact the workpiece at a relatively uniform angle, the first and second electrodes (32,33) having curved surfaces (136,172) separated by a gap that changes along the length of the elongated slots (134,170).

15. A method of ion implanting a workpiece, comprising:

causing a beam of ions to move along an initial trajectory;
orienting the workpiece at a target location;
causing ions to diverge away from the initial trajectory to scan in a back and forth manner to form a narrow ion beam having an extent at least as wide as the workpiece;
redeflecting said ions by generating a static electric field that both redeflects and accelerates ions after the divergence of the beam in both a parallelizing plane and a cross plane orthogonal to the parallelizing plane; and
moving the workpiece in a back and forth manner to cause ions passing through the static electric field to treat an entire workpiece surface.

16. A method according to claim 15, wherein generating the static electric field is performed by biasing first and second arcuate metallic electrodes relative each other at a location downstream from the region ions diverge from the initial trajectory, so that ions enter an elongated aperture in the first arcuate electrode, are deflected by the static electric field that is non-uniform due to spacing variations between the first and second arcuate electrodes, and pass through an aperture in the second electrode before striking the workpiece.

Patentansprüche

1. Ionenimplantiersystem zum steuerbaren Behandeln eines Werkstücks, das folgendes aufweist:

Quellenmittel (12) zum Vorsehen von Ionen, um ein Werkstück zu behandeln;
Tragmittel (50) zum Orientieren des Werkstücks an einem Ort relativ zu den Quellenmitteln;
Strahlbildemittel (16, 17) zum Veranlassen, daß Ionen von den Quellenmitteln emittiert werden, um einer anfänglichen Trajektorie zu folgen;
Elektrodenmittel (26, 28) zum Ablenken von Ionen in den Ionenstrahl weg von der anfänglichen Trajektorie, um einen gesteuerten Betrag;
Linsenmittel zum erneuten Ablenken von Ionen, bevor die Ionen auf das Werkstück auftreffen bzw. aufschlagen; und
Steuermittel (29) mit einem Ausgang gekoppelt mit den Elektrodenmitteln, um das Ablenken des Ionenstrahls einzustellen, und um dadurch die Ionenstrahlbehandlung des Werkstücks zu steuern;
dadurch **gekennzeichnet**, daß die Linsenmittel erste und zweite beabstandete Elektroden (32, 33) aufweisen, die erste und zweite langgestreckte Schlitze (134, 170) definieren, um es Ionen zu gestatten, in ein räumlich nichtgleichförmiges elektrisches Feld einzutreten, das Ionen veranlaßt, verschiedenen bzw. unterschiedlichen Trajektorien zu folgen, und zwar nach der Ablenkung durch die Elektrodenmittel, um erneut abgelenkt zu werden, und auf das Werkstück aufzutreffen, und zwar unter einem relativ gleichförmigen Winkel, wobei die ersten und zweiten langgestreckten Schlitze (134, 170) in der Breite von einem mittleren Bereich der ersten und zweiten Schlitze zu einem äußeren Teil der ersten und zweiten Schlitze variieren.

2. Ionenimplantiersystem nach Anspruch 1, wobei die ersten und zweiten Elektroden (32, 33) gekrümmte

Elektrodenoberflächen (136, 172) besitzen, die die Dicken der ersten und zweiten Elektroden in einer Region variieren, die die langgestreckten Schlitze, durch die der Ionenstrahl auf seinem Weg zu dem Werkstück läuft, begrenzt.

3. Ionenimplantiersystem nach Anspruch 1, das mindestens zwei zusätzliche Elektroden (34) aufweist, die aus beabstandeten, parallelen Elektrodenplatten bestehen, die Aperturen bzw. Öffnungen besitzen, um Ionen zu übertragen bzw. durchzulassen, die durch die langgestreckten Schlitze (134, 170) zu dem Werkstück laufen.

4. Ionenimplantiersystem nach Anspruch 1, wobei die gekrümmten Oberflächen (136, 172) der beabstandeten ersten und zweiten Elektroden (32, 33) eine unterschiedliche Krümmung besitzen, um eine Spalttrennung zwischen den gekrümmten Oberflächen entlang der Länge der ersten und zweiten Schlitze (134, 170) zu variieren.

5. Ionenimplantiersystem nach Anspruch 1, das eine Linsenleistungsversorgung (62) aufweist, und zwar zum Vorspannen der ersten und zweiten Elektroden (32, 33) bei unterschiedlichen Konstanten elektrischen Potentialen, um ein statisches elektrisches Feld in einer Region zwischen den ersten und zweiten Elektroden zu erzeugen.

6. Ionenimplantiersystem nach Anspruch 1, das Beschleunigungsmittel (30) zum Beschleunigen von Ionen, die um den gesteuerten Betrag zu den Ionen, die auf das Werkstück auftreffen, abgelenkt wurden, wobei die Beschleunigungsmittel folgendes aufweisen:

erste und zweite bogenförmige bzw. gewölbte Eintrittselektroden (32, 33), die die ersten und zweiten beabstandeten Elektroden aufbauen, wobei die ersten und zweiten langgestreckten Schlitze (134, 170) davon Durchlässe definieren, die symmmetrisch um eine Mittelinie sind, und die breiter an Stellen beabstandet von der Mittellinie als bei der Mittellinie sind;
eine Vielzahl von zusätzlichen beabstandeten parallelen Elektrodenplatten (34) zum Beschleunigen der Ionen auf eine Aufprall- bzw. Auftreffenergie; eine Vielzahl von Isolatoren (70), die die Platten trennen; und
Leistungsversorgungsmittel (62, 63) zum Vorspannen der gewölbten Eintrittselektrode relativ zu der Vielzahl von parallelen Elektrodenplatten, so daß eine erste (34a) der zusätzlichen Elektroden auf einer fixierten Spannung durch eine Hochspannungsleistungsversorgung (63) gehalten wird, eine zweite (34e) der zusätzlichen Elektroden geerdet ist, und die Eintrittselektrode (33) durch eine Linsenleistungsversorgung (62) auf eine Spannung höher als die erste zusätzliche Elektrode (34a) vorgespannt ist, wodurch positiv geladene Ionen auf eine gesteuerte Ionenenergie beschleunigt werden, wenn sie auf das Werkstück auftreffen bzw. aufschlagen.

7. Ionenbeschleuniger, der zur Verwendung mit einem Ionenimplantiersystem nach Anspruch 1 geeignet ist, wobei der Ionenbeschleuniger folgendes aufweist:

erste und zweite Eintrittselektroden (32, 33), und zwar vorgespannt auf Spannungen zum Erzeugen eines nicht-gleichförmigen elektrischen Feldes, das Ionen veranlaßt, diversen Trajektorien zu folgen, und zwar innerhalb des Implantiersystems, um abgelenkt zu werden und auf ein Werkstück unter einem relativ gleichförmigen Winkel aufzutreffen, wobei die Eintrittselektroden langgestreckte Schlitze (134, 170) definieren, die sich dorthindurch erstrecken, die im allgemeinen symmetrisch um eine Ebene sind, die durch die ersten und zweiten Eintrittselektroden verläuft, wobei die Schlitze jeweils eine Breite besitzen, die über die Länge der Schlitze variiert;
eine Vielzahl von zusätzlichen beabstandeten Elektroden (34) zum Beschleunigen der Ionen auf eine Auftreff- bzw. Aufprallenergie, bevor sie auf das Werkstück auftreffen;
eine Vielzahl von Isolatoren (70), die die zusätzlichen Elektroden trennen; und
Leistungsversorgungsmittel (62, 63) zum elektrischen Vorspannen der ersten und zweiten Eintrittselektroden auf elektrische Potentiale, die von der Vielzahl der zusätzlichen Elektroden verschieden sind, um das nicht-gleichförmige elektrische Feld zu erzeugen und um elektrisch die Vielzahl von zusätzlichen Elektroden zum Beschleunigen der Ionen vorzuspannen.

8. Ionenbeschleuniger nach Anspruch 7, wobei eine Schlitzbreite kleiner bei der Mitte des Schlitzes (134, 170) ist und sich bei Positionen entfernt von der Mitte verbreitert.

9. Ionenbeschleuniger nach Anspruch 8, wobei der Schlitz (134, 170) sich gleichförmig an gegenüberliegenden Seiten des Schlitzes verbreitert.

10. Ionenbeschleuniger nach Anspruch 7, wobei die ersten und zweiten Eintrittselektroden (32,33) gekrümmte Oberflächen besitzen, die voneinander beabstandet sind, und zwar durch einen variablen Spalt entlang der Länge der langgestreckten

Schlitze (134, 170).

11. Ionenbeschleuniger nach Anspruch 7, wobei eine Dicke von mindestens einer der ersten und zweiten Eintrittselektroden (32, 33) sich entlang einer Länge des langgesreckten Schlitzes (134, 170) verändert.

12. Ionenimplantiersystem zum steuerbaren Behandeln eines Werkstücks, das folgendes aufweist:

Quellenmittel (12) zum Vorsehen von Ionen, um ein Werkstück zu behandeln;
Tragmittel (50) zum Orientieren des Werkstücks bei einem Ort relativ zu den Quellenmitteln;
Strahlbildemittel (16, 17) zum Veranlassen, daß Ionen, die von den Quellenmitteln emittiert werden, einer anfänglichen Trajektorie folgen:
Elektrodenmittel (26, 28) zum Ablenken von Ionen in dem Ionenstrahl weg von der anfänglichen Trajektorie, und zwar um einen gesteuerten Betrag;
Linsenmittel zum erneuten Ablenken von Ionen, und zwar bevor die Ionen auf das Werkstück auftreffen; und
Steuermittel (29) mit einem Ausgang gekoppelt mit den Elektrodenmitteln, um das Ablenken des Ionenstrahls einzustellen, und um dadurch die Ionenstrahlbehandlung des Werkstücks zu steuern;
dadurch **gekennzeichnet,** daß die Linsenmittel erste und zweite beabstandete Elektroden (32, 33) aufweisen, die erste und zweite langgestreckte Schlitze (134, 170) definieren, um es Ionen zu gestatten, in ein räumlich nichtgleichförmiges elektrisches Feld einzutreten, das Ionen veranlaßt, verschiedenen bzw. unterschiedlichen Trajektorien zu folgen, und zwar nach der Ablenkung durch die Elektrodenmittel, um erneut abgelenkt zu werden und auf das Werkstück unter einem relativ gleichförmigen Winkel aufzutreffen, wobei mindestens eine der ersten und zweiten Elektroden (32, 33) eine Dicke besitzt, die sich entlang der Länge der langgestreckten Schlitze (134, 170) verändert.

13. Ionenimplantiersystem nach Anspruch 12, wobei die ersten und zweiten beabstandeten Elektroden (32, 33) erste und zweite bogenförmige bzw. gewölbte Oberflächen (136, 172) besitzen, die voneinander beabstandet sind, und zwar um einen Spaltabstand, der über die Länge der langgestreckten Schlitze (134, 170) variiert.

14. Ionenimplantiersystem zum steuerbaren Behandeln eines Werkstücks, das folgendes aufweist:

Quellenmittel (12) zum Vorsehen von Ionen, um ein Werkstück zu behandeln;
Tragmittel (50) zum Orientieren des Werkstücks an einem Ort relativ zu den Quellenmitteln;
Strahlbildemittel (16, 17) zum Veranlassen, daß Ionen, die von den Quellenmitteln emittiert werden, einer anfänglichen Trajektorie folgen;
Elektrodenmittel (26, 28) zum Ablenken von Ionen in dem Ionenstrahl weg von der anfänglichen Trajektorie, und zwar um einen gesteuerten Betrag;
Linsenmittel zum erneuten Ablenken von Ionen, und zwar bevor die Ionen auf das Werkstück auftreffen; und
Steuermittel (29) mit einem Ausgang gekoppelt mit den Elektrodenmitteln, um des Ablenken des Ionenstrahls einzustellen, und um dadurch die Ionenstrahlbehandlung des Werkstücks zu steuern;
dadurch **gekennzeichnet,** daß die Linsenmittel erste und zweite beabstandete Elektroden (32, 33) aufweisen, die erste und zweite langgestreckte Schlitze (134, 170) definieren, um es Ionen zu gestatten, in ein räumlich nichtgleichförmiges elektrisches Feld einzutreten, das Ionen veranlaßt verschiedenen bzw. unterschiedlichen Trajektorien nach der Ablenkung durch die Elektrodenmittel zu folgen, um erneut abgelenkt zu werden und auf das Werkstück unter einem relativ gleichförmigen Winkel aufzutreffen, wobei die ersten und zweiten Elektroden (32, 33) gekrümmte Oberflächen (136, 172) besitzen, die durch einen Spalt getrennt sind, der sich entlang der Länge der langgestreckten Schlitze (134, 170) verändert.

15. Verfahren zum Ionenimplantieren eines Werktücks, das folgendes aufweist:

Veranlassen, daß ein Strahl von Ionen sich entlang einer anfänglichen Trajektorie bewegt;
Orientieren des Werkstück an einem Ziel- bzw. Targetort;
Veranlassen, daß Ionen weg von der anfänglichen Trajektorie divergieren, um auf eine vor-und-zurück-Art zu scannen bzw. abzutasten, um einen schmalen Ionenstrahl zu bilden, und zwar mit einem Ausmaß mindestens so breit wie das Werkstück;
erneutes Ablenken der Ionen durch Erzeugen eines statischen elektrischen Feldes, das sowohl die Ionen erneut ablenkt als auch beschleunigt, und zwar nach der Divergenz des Strahls in sowohl einer parallelen Ebene als auch einer Querebene, die orthogonal zu der parallelen Ebene ist; und
Bewegen des Werkstücks auf eine vor-und-

zurück-Art, um Ionen zu veranlassen, durch das statische elektrische Feld zu laufen, um eine gesamte Werkstückoberfläche zu behandeln.

16. Verfahren nach Anspruch 15, wobei das Erzeugen des statischen elektrischen Felds durchgeführt wird durch Vorspannen von ersten und zweiten bogenförmigen bzw. gewölbten metallischen Elektroden relativ zueinander, und zwar an einem Ort stromabwärts von der Region, in der Ionen von der anfänglichen Trajektorie divergieren, so daß Ionen in eine langgestreckte Apertur in der ersten gewölbten Elektrode eintreten, durch das statische elektrische Feld, das nicht gleichförmig ist, und zwar aufgrund von Abstandsvariationen zwischen den ersten und zweiten gewölbten Elektroden, abgelenkt werden, und durch eine Apertur bzw. Öffnung in der zweiten Elektrode laufen, bevor sie auf das Werkstück auftreffen.

Revendications

1. Système d'implantation ionique permettant de traiter sous contrôle une pièce d'usinage, comprenant :

un moyen formant une source (12) servant à fournir des ions pour traiter une pièce d'usinage ;
un moyen formant un support (50) servant à orienter la pièce d'usinage à un emplacement par rapport au moyen formant une source ;
des moyens formant un faisceau (16 et 17) faisant en sorte que des ions émis par le moyen formant une source suivent une trajectoire initiale ;
des moyens formant des électrodes (26 et 28) servant à dévier des ions dans ledit faisceau ionique en s'éloignant de ladite trajectoire initiale suivant une quantité contrôlée ;
un moyen formant une lentille pour dévier à nouveau des ions avant que lesdits ions viennent heurter la pièce d'usinage ; et
un moyen de commande (29) ayant une sortie couplée auxdits moyen formant les électrodes pour régler la déviation dudit faisceau ionique et permettre ainsi de contrôler le traitement par faisceau ionique de la pièce d'usinage ;
caractérisé en ce que le moyen formant une lentille comprend une première et une seconde électrodes espacées (32 et 33) qui définissent une première et une seconde fentes allongées (134 et 170) permettant aux ions d'entrer dans un champ électrique spatialement non uniforme, ce qui a pour effet que les ions suivant des trajectoires diverses après la déviation par les moyens formant les électrodes sont déviés à nouveau et heurtent la pièce d'usinage suivant un angle relativement uniforme, la première et la seconde fentes allongées (134 et 170) variant en largeur depuis une zone centrale de la première et de la seconde fentes vers une partie extérieure de ladite première et de ladite seconde fentes.

2. Système d'implantation ionique selon la revendication 1, dans lequel la première et la seconde électrodes (32 et 33) ont des surfaces d'électrodes incurvées (136 et 172) qui font varier les épaisseurs des première et seconde électrodes dans une zone limitant les fentes allongées à travers lesquelles le faisceau ionique passe sur sa trajectoire jusqu'à la pièce d'usinage.

3. Système d'implantation ionique selon la revendication 1, comprenant au moins deux électrodes supplémentaires (34) qui se composent de plaques d'électrodes parallèles espacées, ayant des ouvertures permettant de transmettre des ions traversant les fentes allongées (134 et 170) jusqu'à la pièce d'usinage.

4. Système d'implantation ionique selon la revendication 1, dans lequel les surfaces incurvées (136 et 172) des première et seconde électrodes espacées (32 et 33) ont une courbure différente pour faire varier une séparation d'espace entre les surfaces incurvées sur la longueur de la première et de la seconde fentes (134 et 170).

5. Système d'implantation ionique selon la revendication 1, comprenant une alimentation de lentille (62) servant à polariser la première et la seconde électrodes (32 et 33) à différents potentiels électriques constants afin de créer un champ électrique statique dans une zone entre la première et la seconde électrodes.

6. Système d'implantation ionique selon la revendication 1, comprenant un moyen d'accélération (30) servant à accélérer les ions déviés suivant ladite quantité contrôlée vers lesdits ions heurtant la pièce d'usinage, le moyen d'accélération comprenant :

une première et une seconde électrodes d'entrée arquées (32 et 33) constituant ladite première et ladite seconde électrodes espacées, ladite première et ladite seconde fentes allongées (134 et 170) des électrodes définissant des passages symétriques autour d'un axe géométrique, qui sont plus larges au niveau des emplacements espacés par rapport à l'axe géométrique qu'au niveau de l'axe géométrique ;
plusieurs plaques supplémentaires d'électro-

des (34) parallèles et espacées permettant d'accélérer lesdits ions pour former une énergie d'impact ;
plusieurs éléments isolants (70) séparant lesdites plaques ; et
des moyens d'alimentation (62 et 63) permettant de polariser ladite électrode d'entrée arquée par rapport à ladite pluralité de plaques d'électrodes parallèles, de sorte qu'une première électrode (34a) parmi les électrodes supplémentaires est maintenue à une tension fixe par une alimentation à tension élevée (63), qu'une seconde électrode supplémentaire (34e) est mise à la masse et que l'électrode d'entrée (33) est polarisée par une alimentation de lentille (62) à une tension supérieure à celle de la première électrode supplémentaire (34a), de sorte que des ions chargés positivement sont accélérés pour constituer une énergie ionique contrôlée au moment de heurter la pièce d'usinage.

7. Accélérateur d'ions adapté pour être utilisé avec le système d'implantation ionique de la revendication 1, l'accélérateur d'ions comprenant :

une première et une seconde électrodes d'entrée (32 et 33) polarisées à des tensions permettant de créer un champ électrique non uniforme, ce qui a pour effet que les ions suivant diverses trajectoires à l'intérieur dudit système d'implantation sont déviés et heurtent une pièce d'usinage suivant un angle relativement uniforme, lesdites électrodes d'entrée définissant des fentes allongées (134 et 170) s'étendant dans ces électrodes, qui sont généralement symétriques autour d'un plan traversant ladite première et ladite seconde électrodes d'entrée, les fentes ayant chacune une largeur qui varie suivant la longueur des fentes ;
plusieurs électrodes supplémentaires espacées (34) servant à accélérer lesdits ions pour constituer une énergie d'impact avant de heurter la pièce d'usinage ;
plusieurs éléments isolants (70) séparant lesdites électrodes supplémentaires ; et
des moyens d'alimentation (62 et 63) servant à polariser électriquement la première et la seconde électrodes d'entrée à des potentiels électriques différents de la pluralité d'électrodes supplémentaires afin de créer le champ électrique non uniforme, et servant à polariser électriquement la pluralité d'électrodes supplémentaires pour accélérer les ions.

8. Accélérateur d'ions selon la revendication 7, dans lequel une largeur de fente est moins importante au centre de la fente (134 et 170) et s'élargit au niveau des positions éloignées du centre.

9. Accélérateur d'ions selon la revendication 8, dans lequel la fente (134 et 170) s'élargit uniformément sur les côtés opposés de la fente.

10. Accélérateur d'ions selon la revendication 7, dans lequel la première et la seconde électrodes d'entrée (32 et 33) ont des surfaces incurvées qui sont espacées par un espace variable sur la longueur desdites fentes allongées (134 et 170).

11. Accélérateur d'ions selon la revendication 7, dans lequel une épaisseur correspondant au moins à une desdites première et seconde électrodes d'entrée (32 et 33) varie sur une longueur de ladite fente allongée (134 et 170).

12. Système d'implantation ionique servant à traiter sous contrôle une pièce d'usinage, comprenant :

un moyen formant une source (12) servant à fournir des ions pour traiter une pièce d'usinage ;
un moyen formant un support (50) servant à orienter la pièce d'usinage au niveau d'un emplacement par rapport au moyen formant la source ;
des moyens formant un faisceau (16 et 17) ayant pour effet que des ions émis par le moyen formant une source suivent une trajectoire initiale ;
des moyens formant des électrodes (26 et 28) servant à dévier des ions dans ledit faisceau ionique en les éloignant de ladite trajectoire initiale suivant une quantité contrôlée ;
un moyen formant une lentille servant à dévier à nouveau des ions avant que lesdits ions viennent heurter la pièce d'usinage ; et
un moyen de commande (29) ayant une sortie couplée auxdits moyens d'électrodes pour régler la déviation dudit faisceau ionique, et permettre ainsi de contrôler un traitement par faisceau ionique de la pièce d'usinage ;
caractérisé en ce que le moyen formant une lentille comprend une première et une seconde électrodes espacées (32 et 33) qui définissent une première et une seconde fentes allongées (134 et 170) permettant aux ions d'entrer dans un champ électrique spatialement non uniforme, ce qui a pour effet que des ions suivant diverses trajectoires après déviation par les moyens formant les électrodes sont déviés à nouveau et heurtent la pièce d'usinage suivant un angle relativement uniforme, au moins une des première et seconde électrodes (32 et 33) ayant une épaisseur qui varie sur la longueur des fentes allongées (134 et 170).

13. Système d'implantation ionique selon la revendication 12, dans lequel la première et la seconde électrodes espacées (32 et 33) ont une première et une seconde surfaces arquées (136 et 172) qui sont séparées par un intervalle d'espace qui varie sur la longueur des fentes allongées (134 et 170).

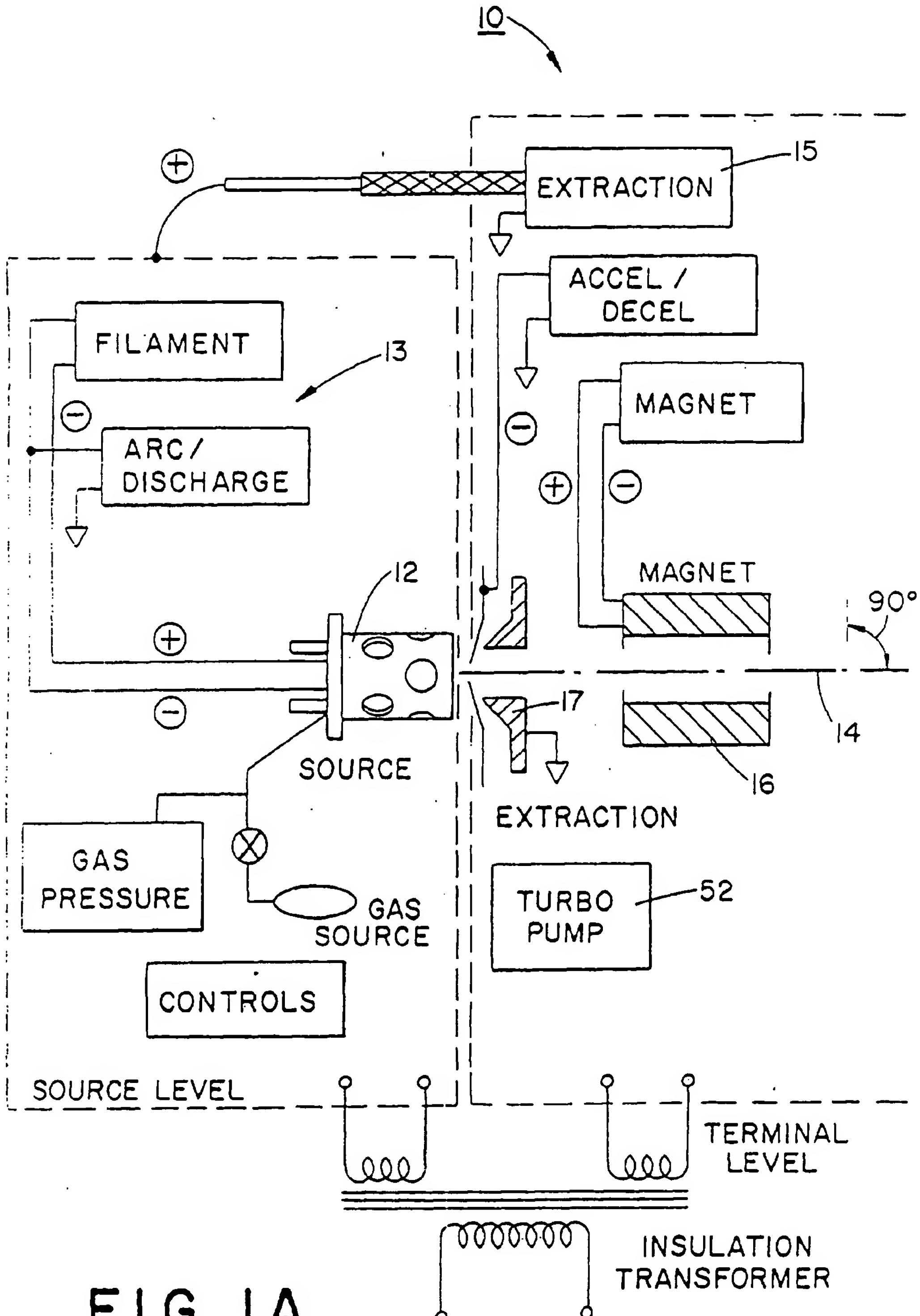
14. Système d'implantation ionique servant à traiter sous contrôle une pièce d'usinage, comprenant :

un moyen formant une source (12) servant à fournir des ions pour traiter une pièce d'usinage ;
un moyen formant un support (50) servant à orienter la pièce d'usinage au niveau d'un emplacement par rapport au moyen formant la source ;
des moyens formant un faisceau (16 et 17) ayant pour effet que des ions émis par le moyen formant une source suivent une trajectoire initiale ;
des moyens formant des électrodes (26 et 28) servant à dévier des ions dans ledit faisceau ionique en les éloignant de ladite trajectoire initiale suivant une quantité contrôlée ;
un moyen formant une lentille servant à dévier à nouveau des ions avant que lesdits ions viennent heurter la pièce d'usinage ; et
un moyen de commande (29) ayant une sortie couplée auxdits moyens d'électrodes pour régler la déviation dudit faisceau ionique, et permettre ainsi de contrôler un traitement par faisceau ionique de la pièce d'usinage ;
caractérisé en ce que le moyen formant une lentille comprend une première et une seconde électrodes espacées (32 et 33) qui définissent une première et une seconde fentes allongées (134 et 170) permettant aux ions d'entrer dans un champ électrique spatialement non uniforme, ce qui a pour effet que des ions suivant diverses trajectoires après déviation par les moyens formant les électrodes sont déviés à nouveau et heurtent la pièce d'usinage suivant un angle relativement uniforme, la première et la seconde électrodes (32 et 33) ayant des surfaces incurvées (136 et 172) séparées par un espace qui varie sur la longueur des fentes allongées (134 et 170).

15. Procédé pour l'implantation ionique d'une pièce d'usinage, comprenant :

l'effet permettant le déplacement d'un faisceau d'ions sur une trajectoire initiale ;
l'orientation de la pièce d'usinage à un emplacement cible ;
l'effet permettant à des ions de diverger en s'éloignant de la trajectoire initiale afin de balayer vers l'arrière et vers l'avant pour former un faisceau ionique étroit ayant une extension au moins aussi large que la pièce d'usinage ;
une nouvelle déviation desdits ions en générant un champ électrique statique qui, à la fois, dévie à nouveau et accélère les ions après la divergence du faisceau, à la fois dans un plan de parallélisation et dans un plan transversal orthogonal par rapport au plan de parallélisation ; et
le déplacement de la pièce d'usinage vers l'arrière et vers l'avant ayant pour effet que les ions traversant le champ électrique statique traitent une surface totale de la pièce d'usinage.

16. Procédé selon la revendication 15, dans lequel la génération du champ électrique statique est réalisée en polarisant la première et la seconde électrodes métalliques arquées, l'une par rapport à l'autre, à un emplacement en aval de la zone où les ions divergent par rapport à la trajectoire initiale, de sorte que des ions, entrant dans une ouverture allongée de la première électrode arquée, sont déviés par le champ électrique statique qui est non uniforme en raison des variations d'espacement entre la première et la seconde électrodes arquées, et traversent une ouverture de la seconde électrode avant de heurter la pièce d'usinage.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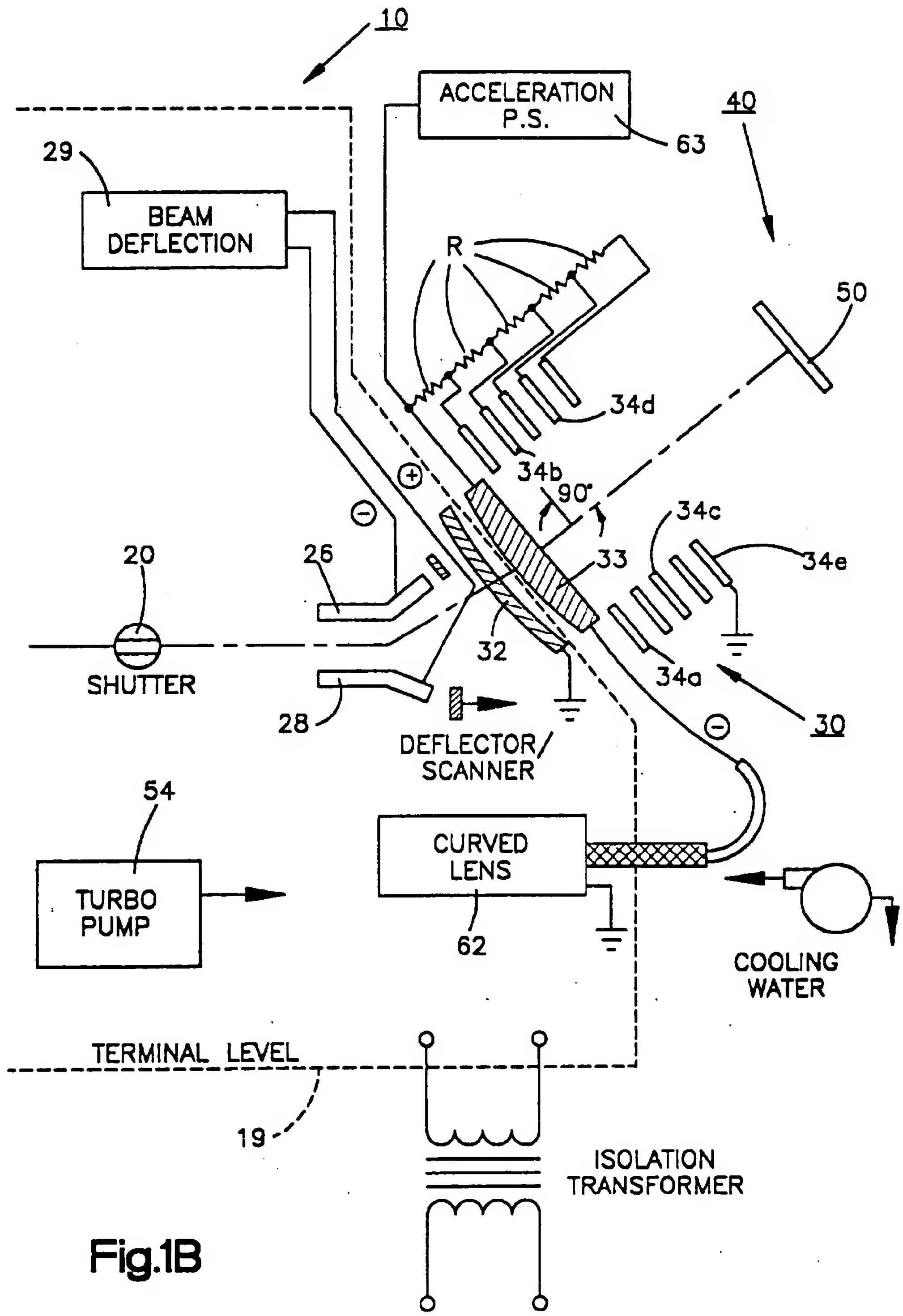
EXTRACTION
15
ACCEL / DECEL
MAGNET
FILAMENT
13
ARC/ DISCHARGE
12
MAGNET
90°
SOURCE
17
14
16
EXTRACTION
GAS PRESSURE
GAS SOURCE
TURBO PUMP
52
CONTROLS
SOURCE LEVEL
TERMINAL LEVEL
INSULATION TRANSFORMER

FIG. 1A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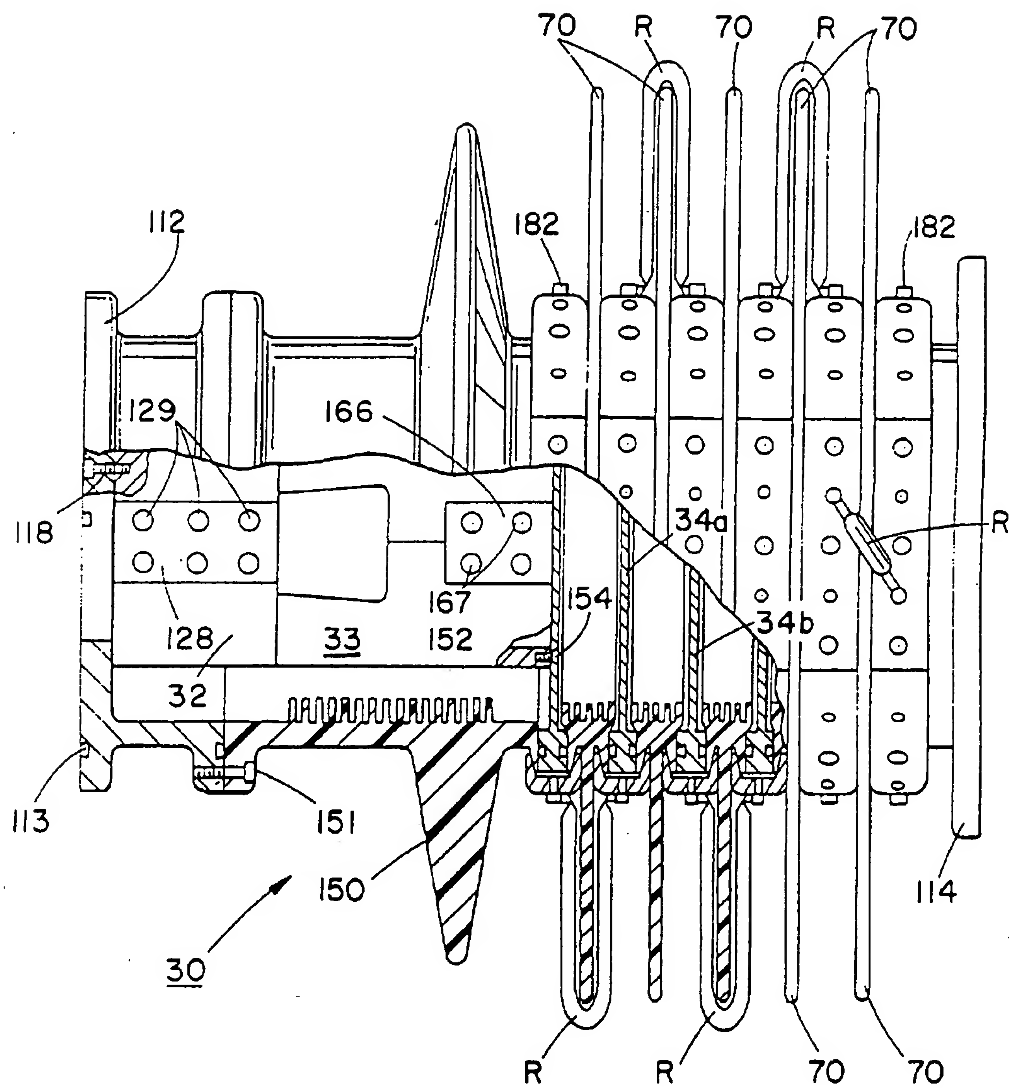
ACCELERATION P.S.
63
40
29
BEAM DEFLECTION
R
50
34d
34b
90°
34c
20
26
33
34e
32
34a
SHUTTER
30
28
DEFLECTOR/ SCANNER
54
CURVED LENS
TURBO PUMP
62
COOLING WATER
TERMINAL LEVEL
19
ISOLATION TRANSFORMER

Fig.1B

FIG. 2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R
70
R
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129
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34b
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30
R
R
70
70

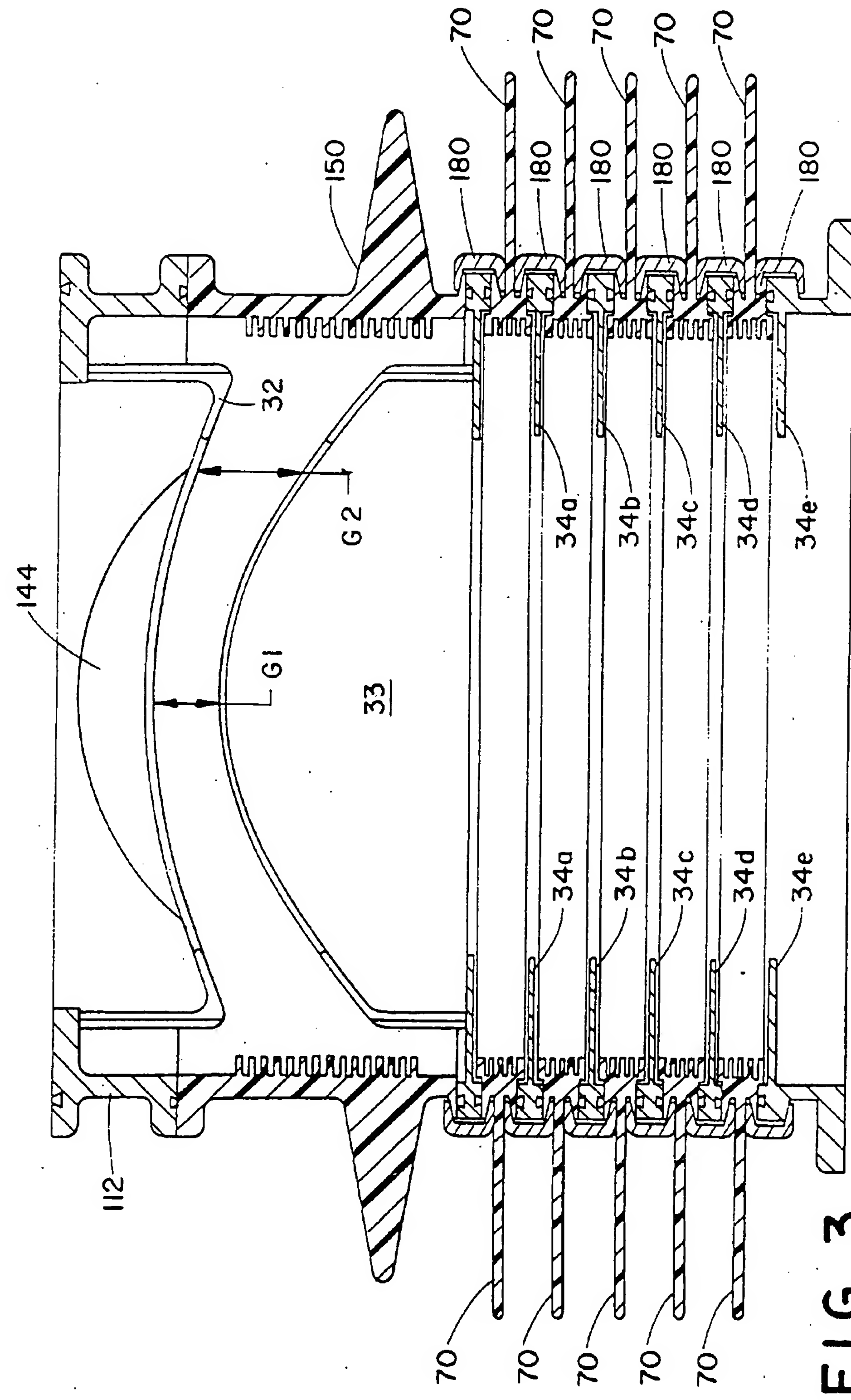

FIG. 3

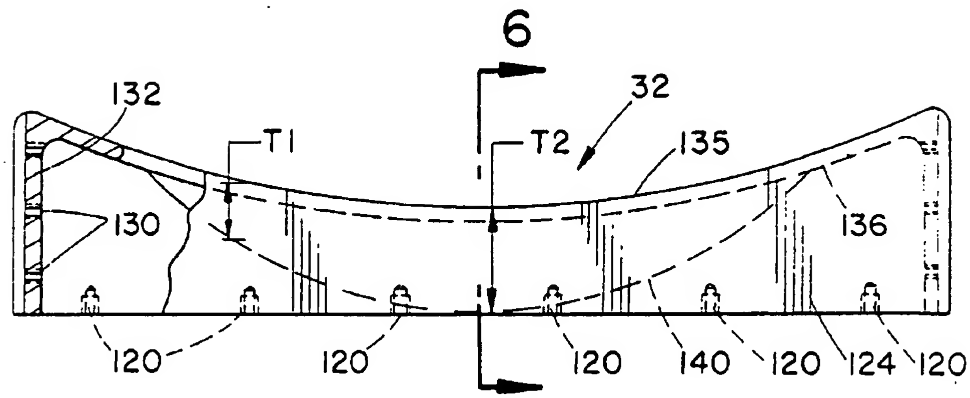

FIG. 5

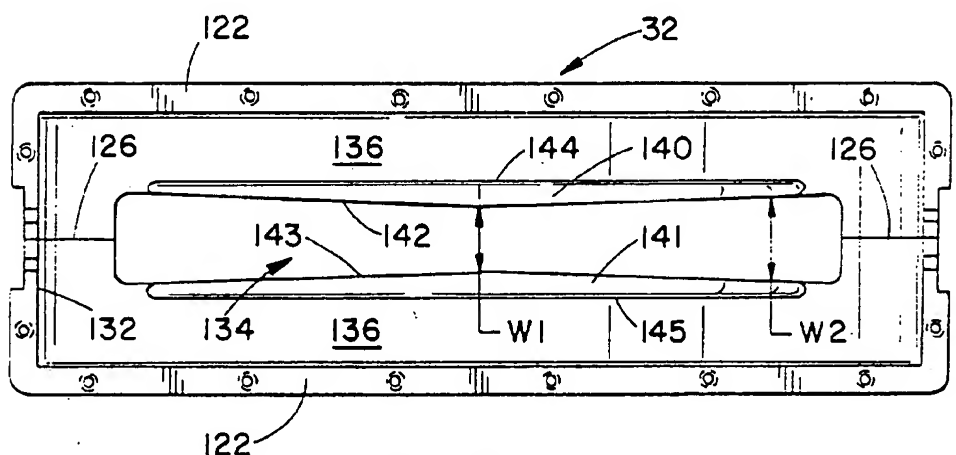

FIG. 4

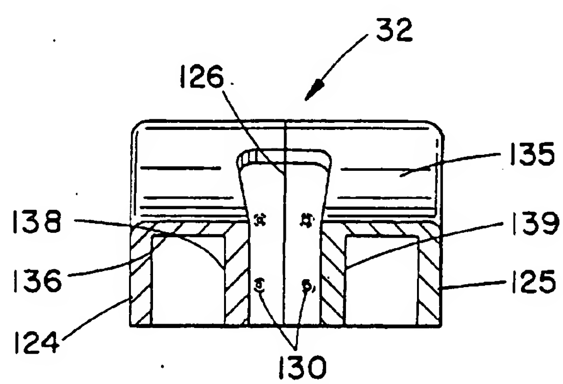

FIG. 6

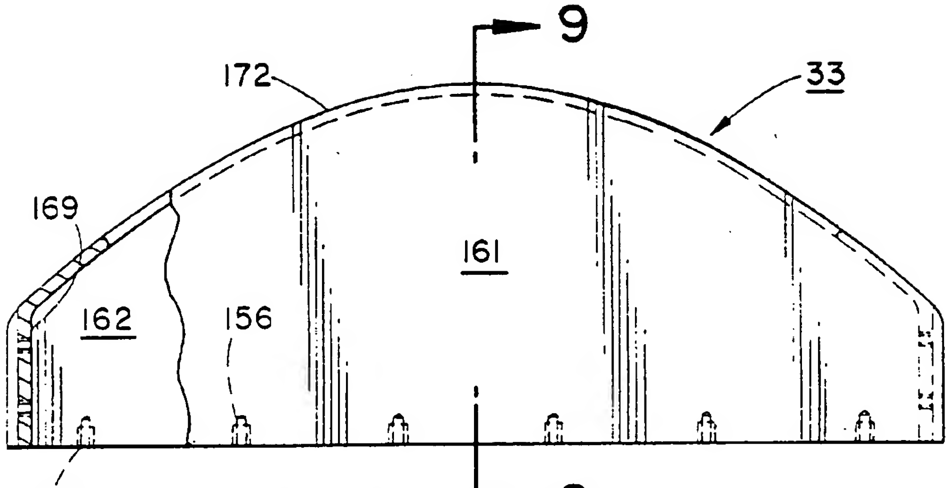

FIG. 8

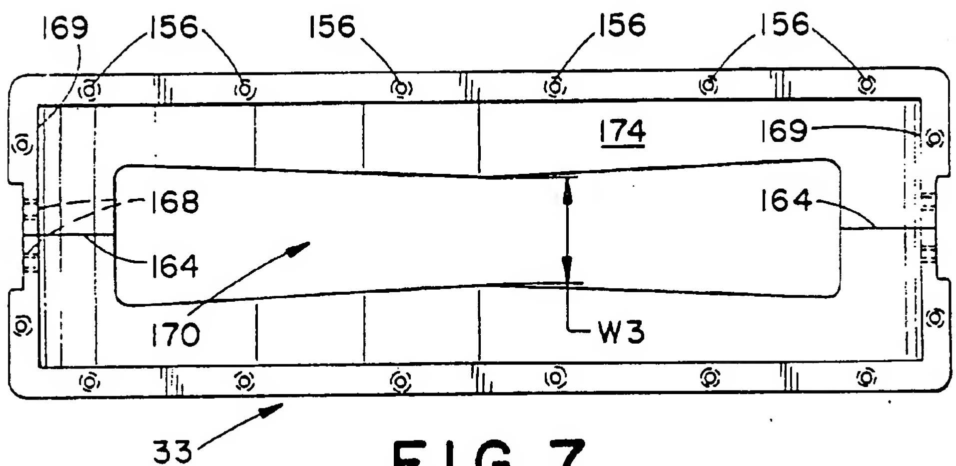

FIG. 7

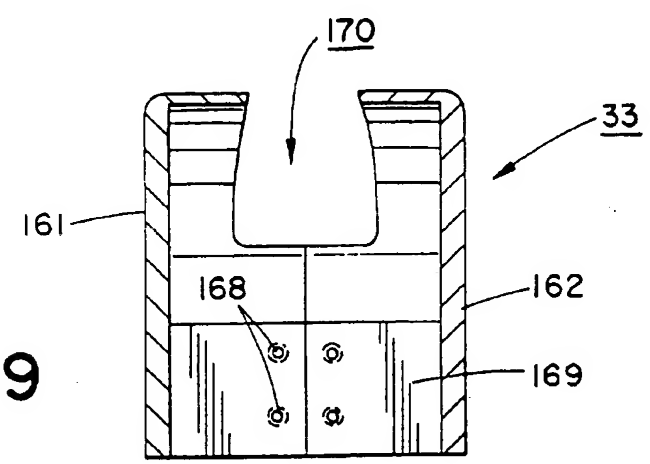

FIG. 9

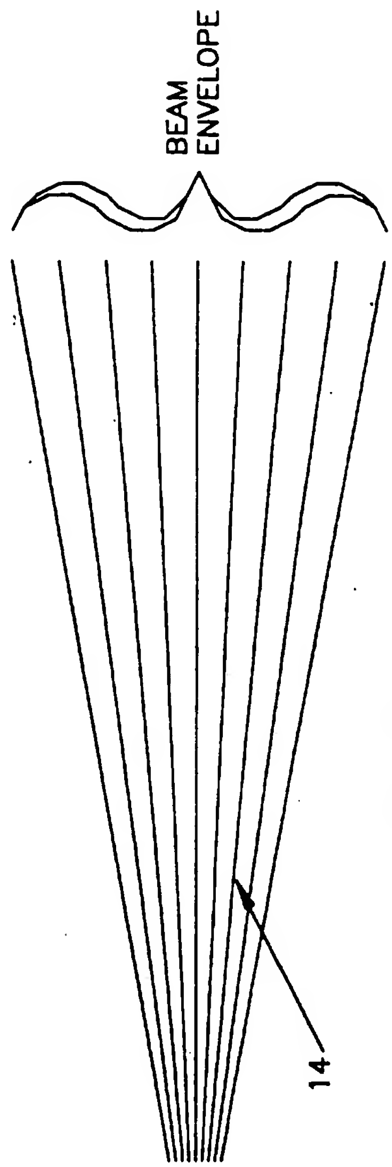

Fig.10

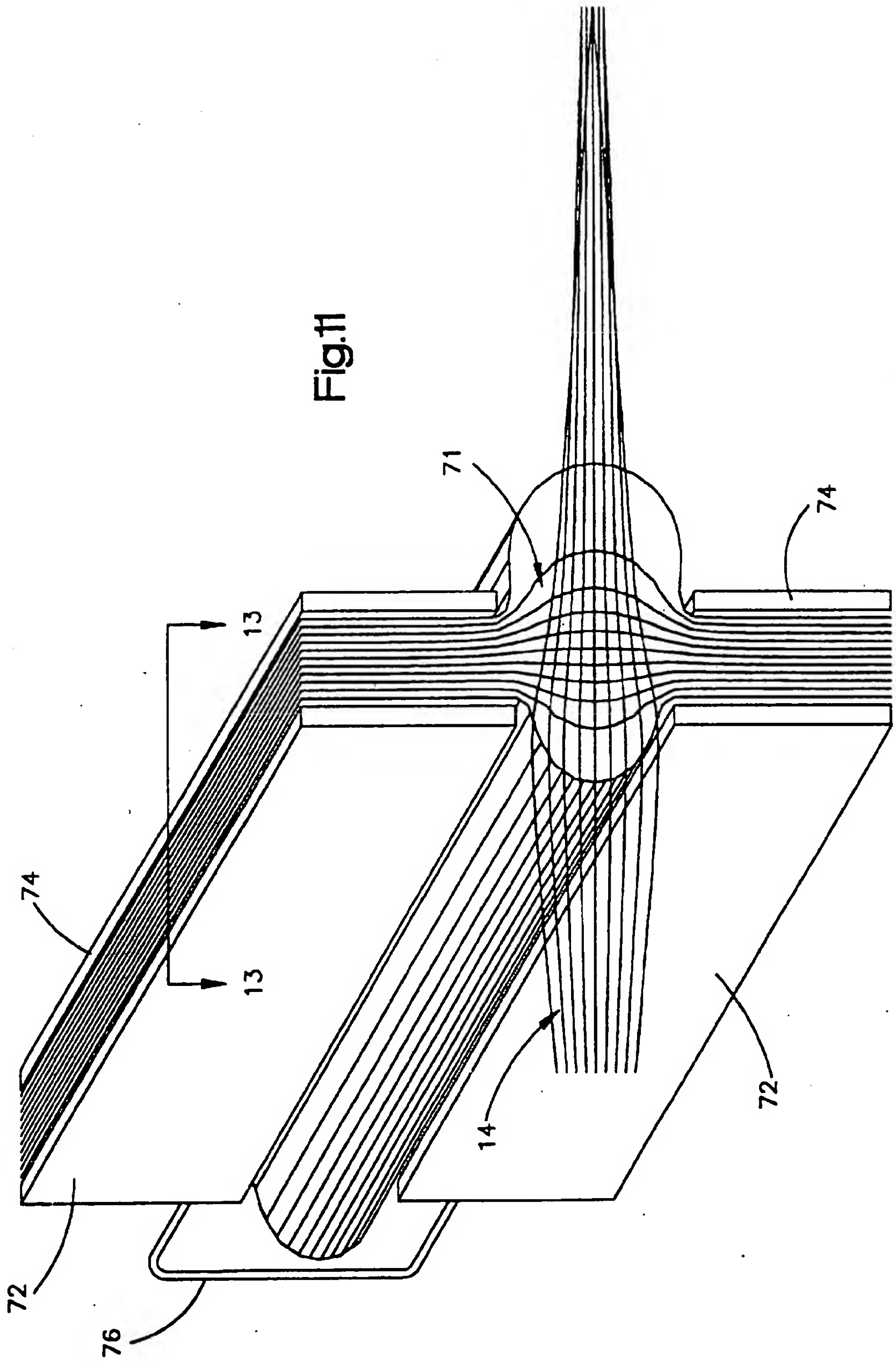

Fig.11

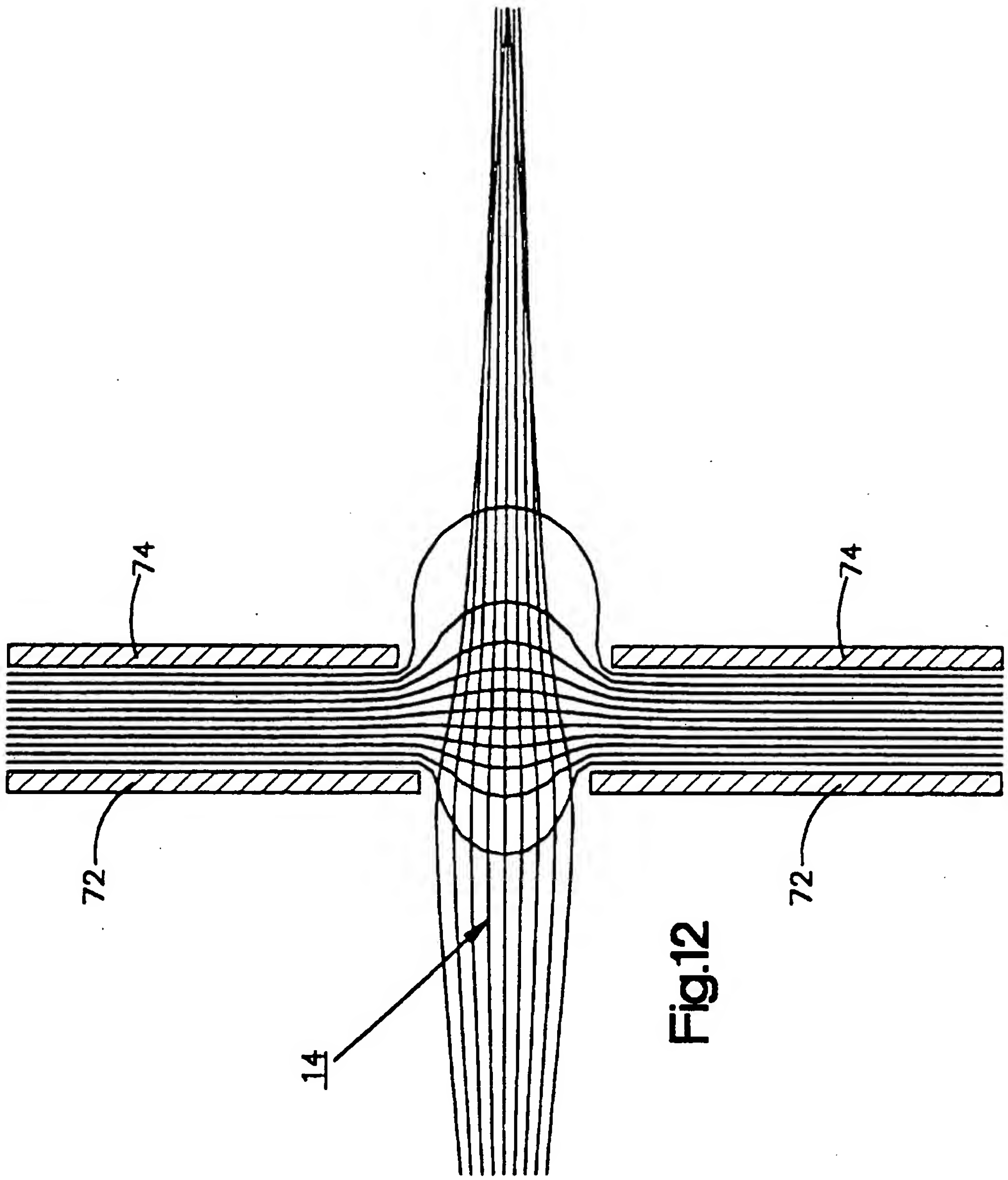

Fig.12

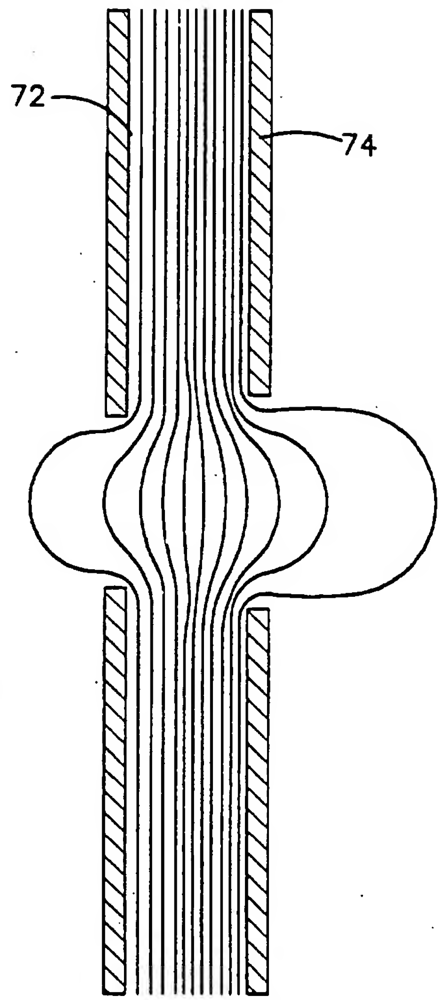

Fig.13

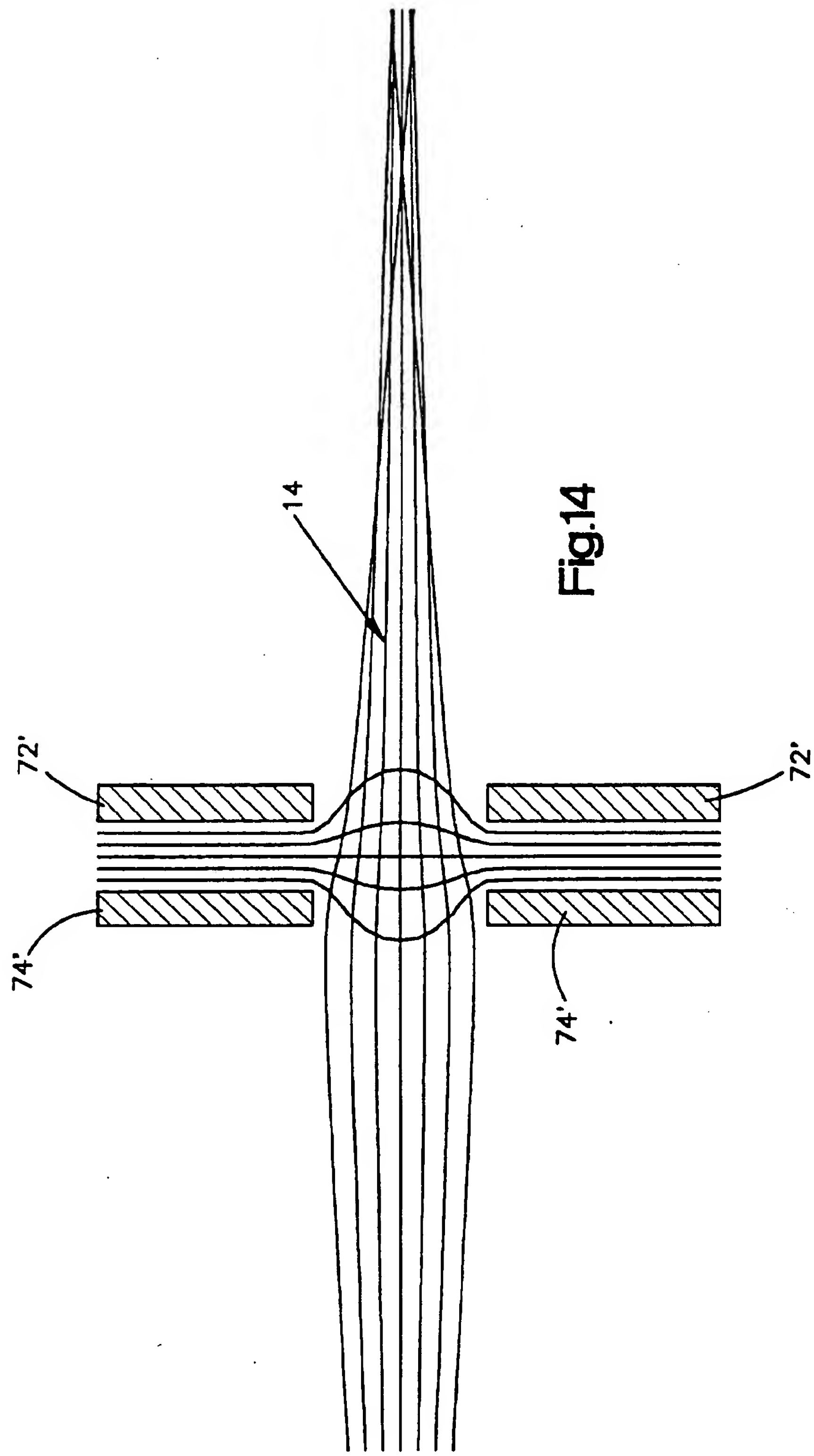

Fig.14

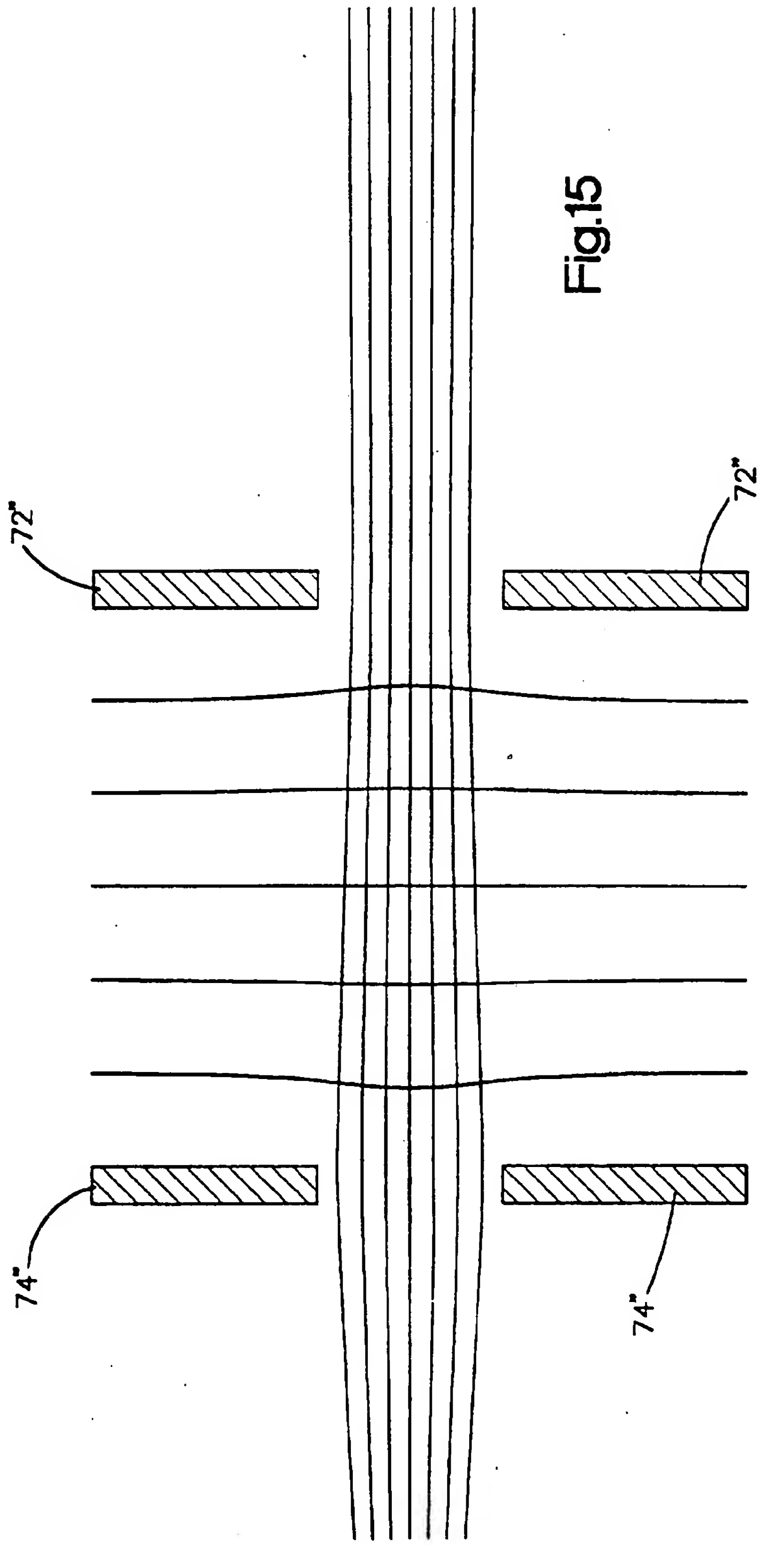

Fig.15

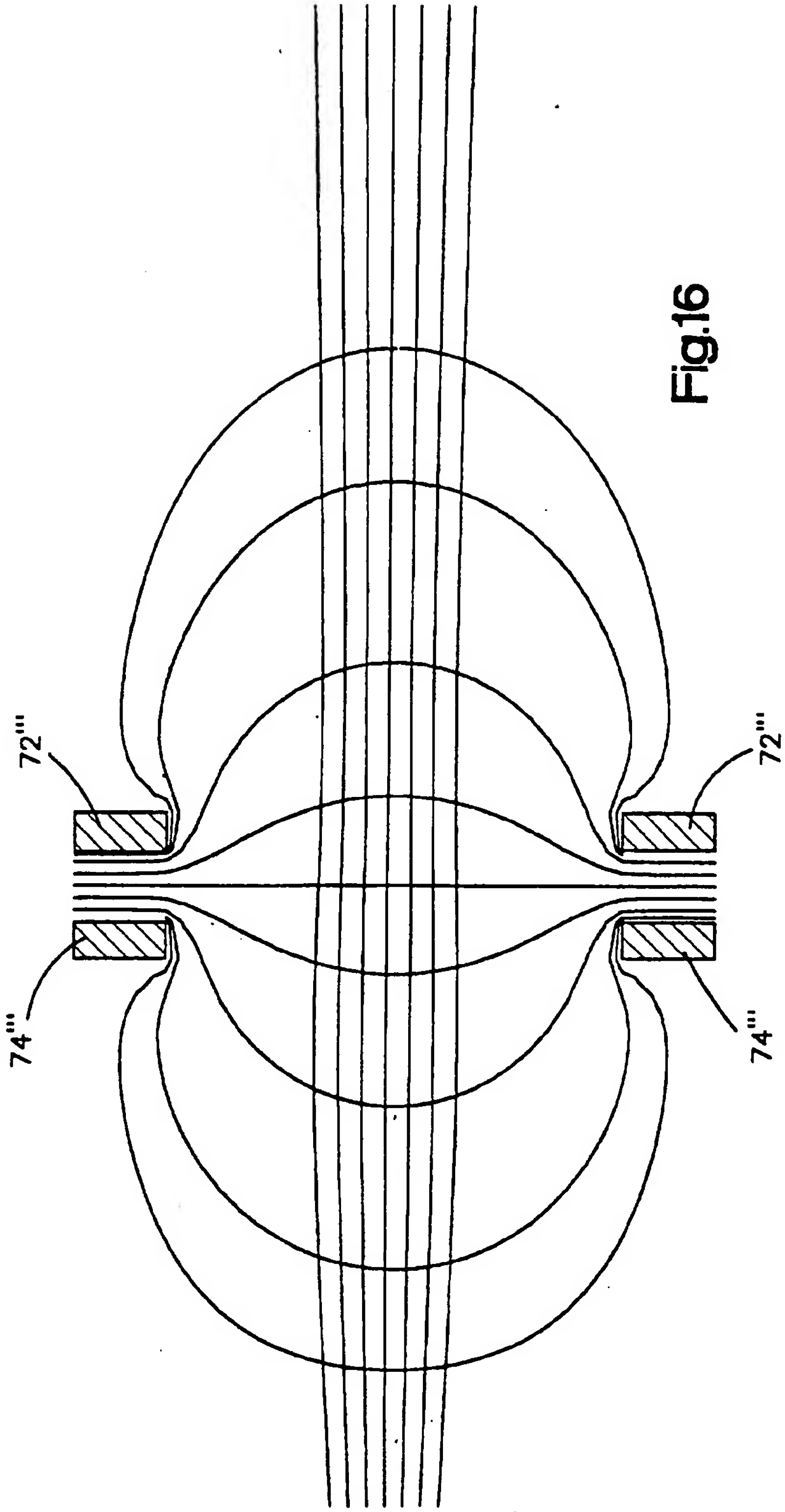

Fig.16

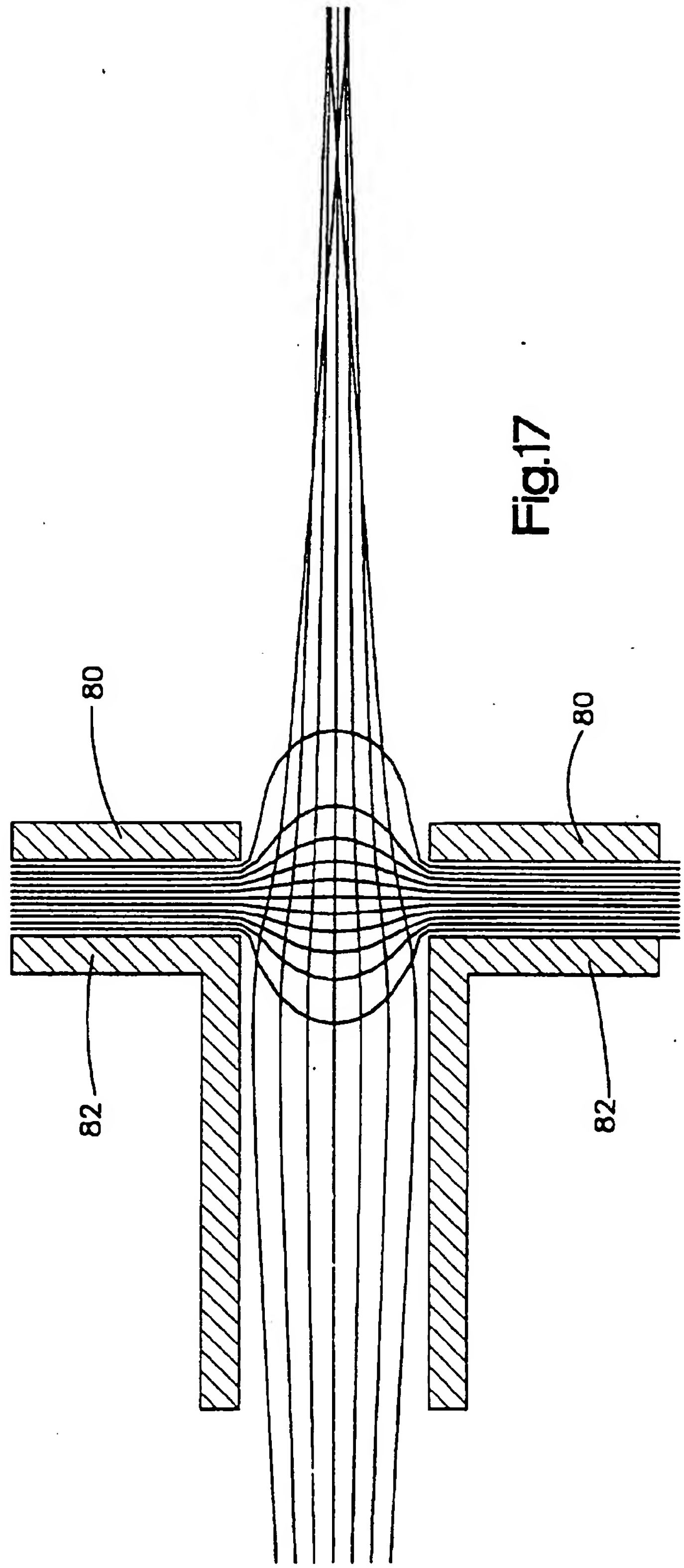

Fig.17